Basic Biomechanics

Chapter 3

Terms

- Mechanics
  - Study of physical actions and forces
- Kinematics:
  - Description of motion (e.g, how fast, how high, etc.) without consideration given to its mass or the forces acting on it.
- Kinetics:
  - The study of forces associated with motion.
  - Example: Pushing on the table may or may not move the table, depending upon the strength and direction of the push

Machines

- The musculoskeletal system is a series of simple machines
- Machines are used to create a mechanical advantage
- They may balance multiple forces
- Enhance force thus reducing the amount of force needed to produce
- Enhance the range of motion or the speed of movement

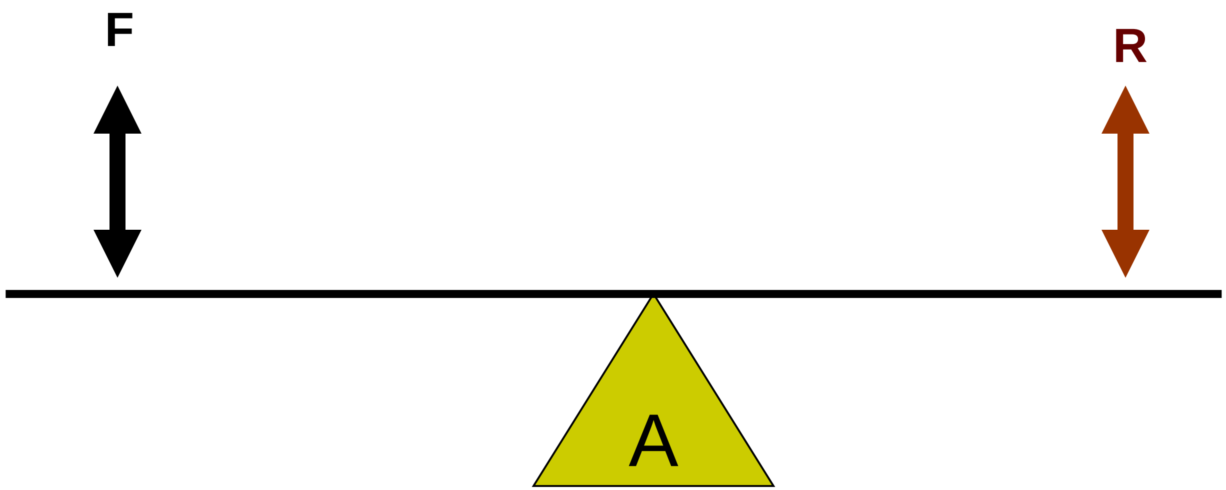
Levers

- Levers are used to alter the resulting direction of the applied force
- A lever is a rigid bar (bone) that turns about an axis of rotation or fulcrum (joint)
- The lever rotates about the axis as a result of a force (from muscle contraction)
- The force acts against a resistance (weight, gravity, opponent, etc.)

Levers

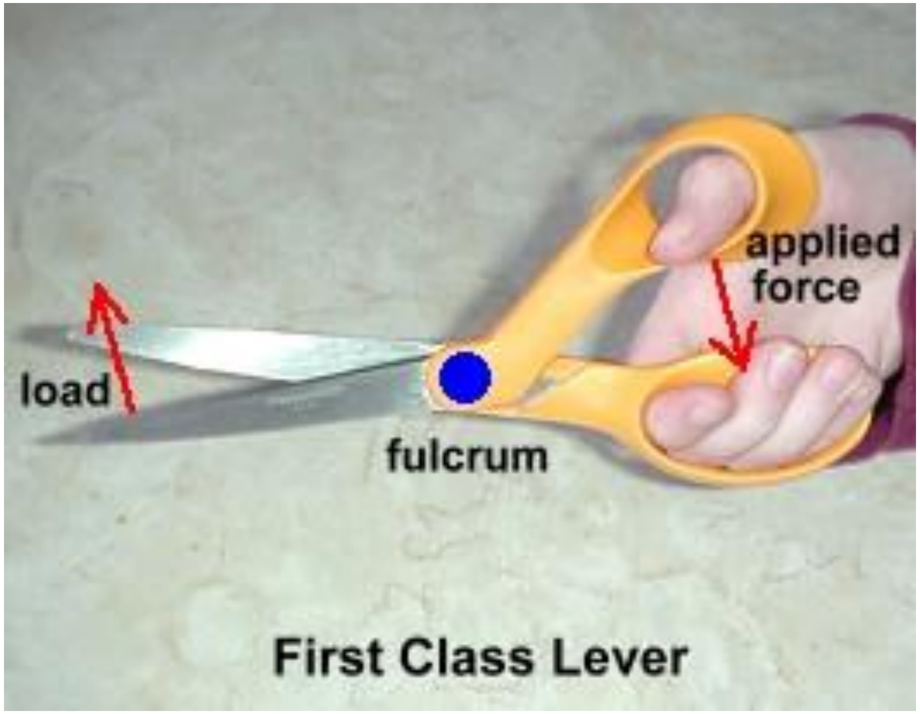
- The relationship of the points determines the type of lever
- The axis (joint), force (muscle insertion point), and the resistance (weight, etc.)

First Class

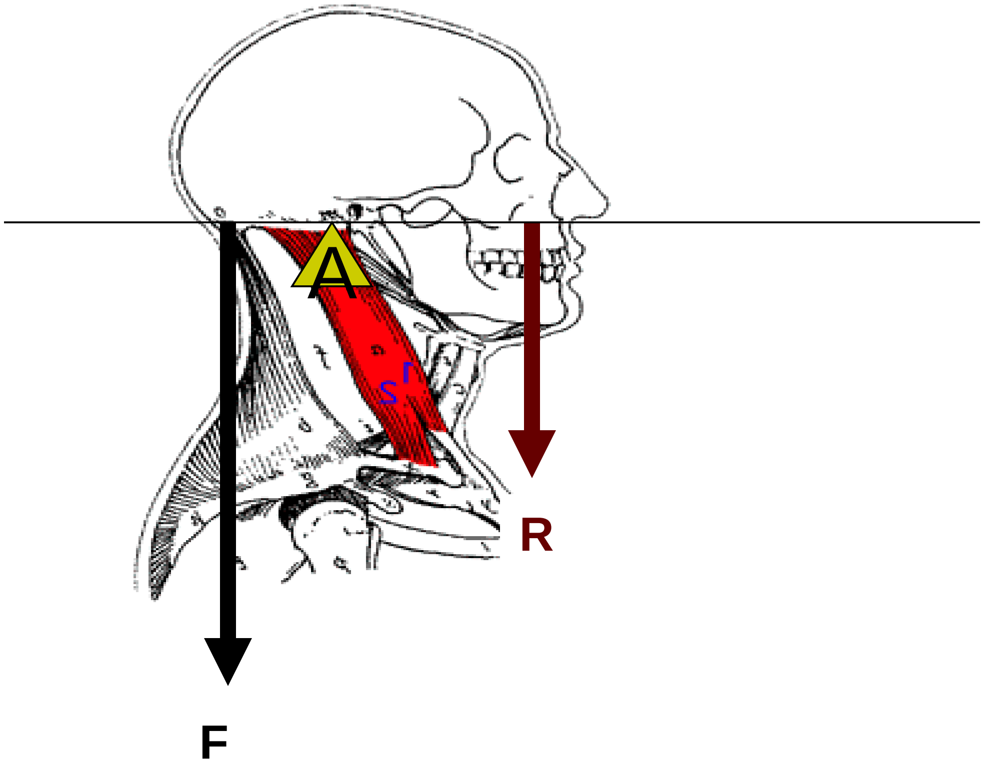


F A R

First Class

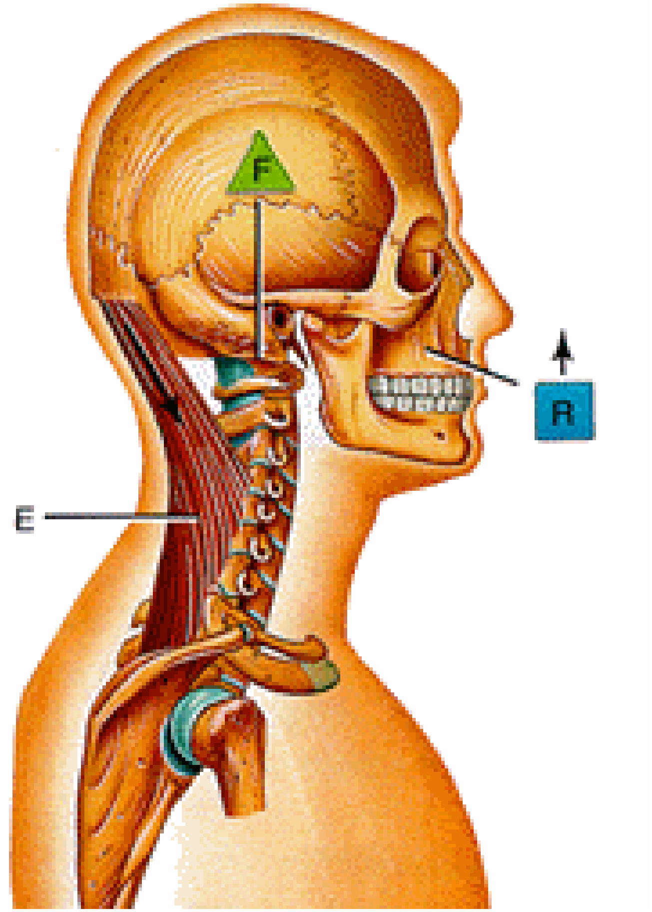


First Class



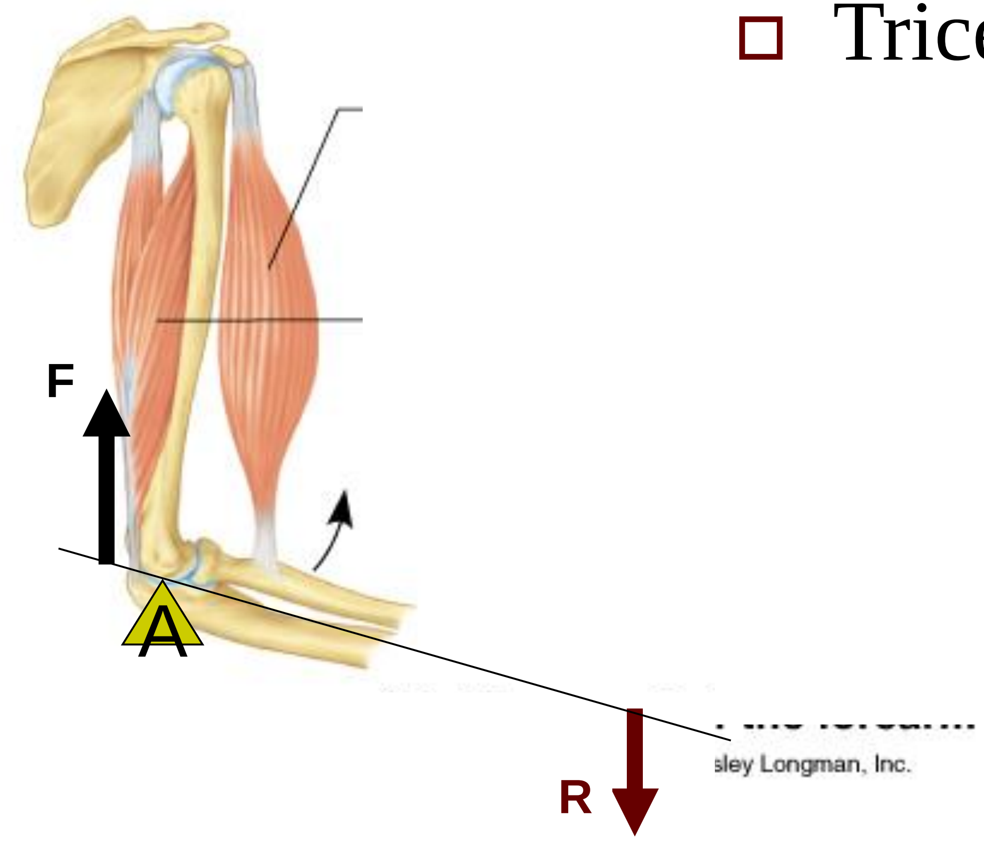
- Neck extension
- Erector spinae and Splenius

First Class



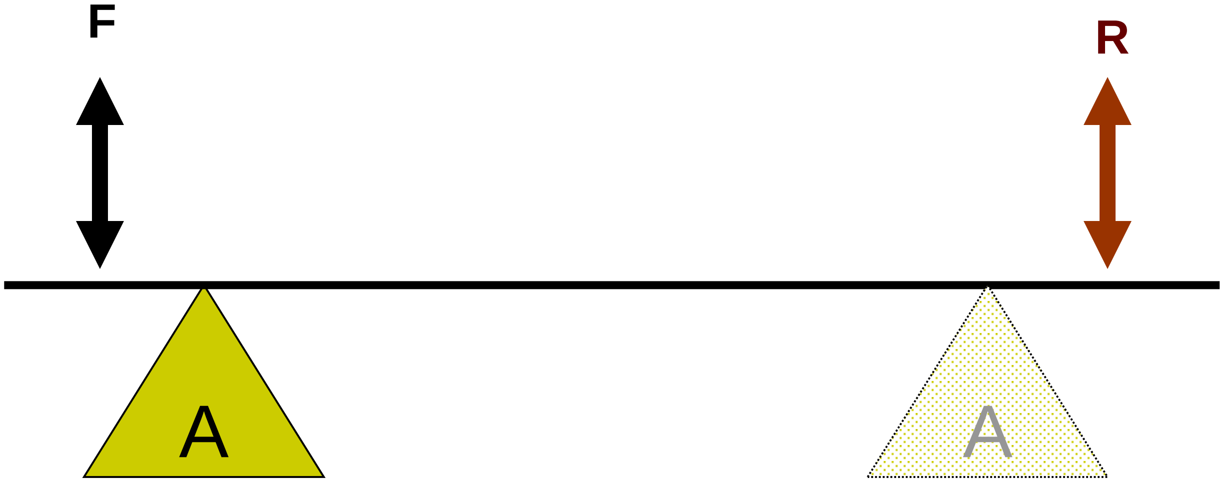
First Class

- Elbow extension
- Triceps



First Class

- Designed for speed and range of motion when the axis is closer to the force
- Designed for strength when the axis is closer to the resistance



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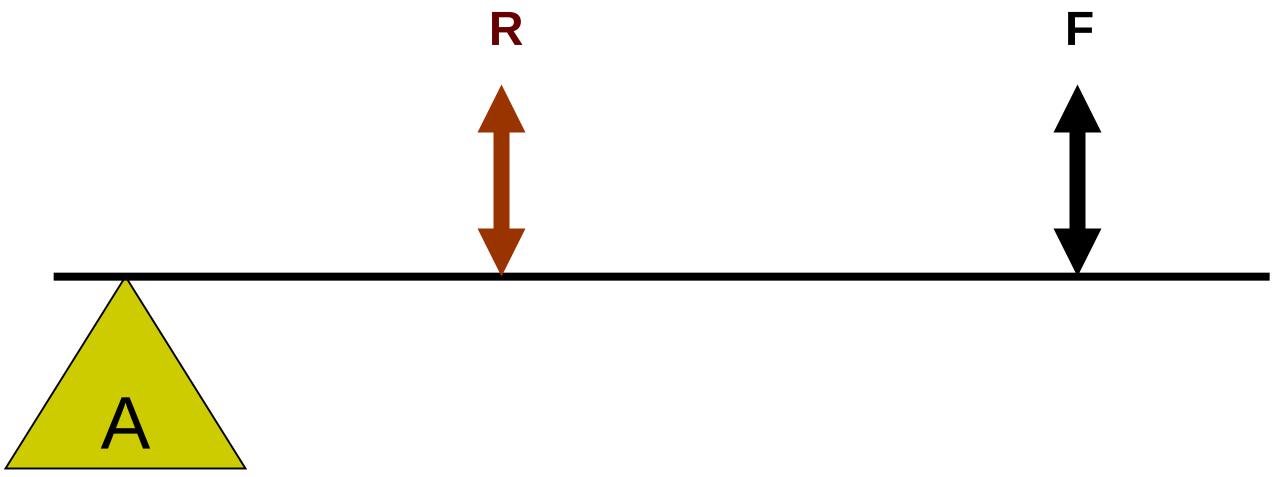
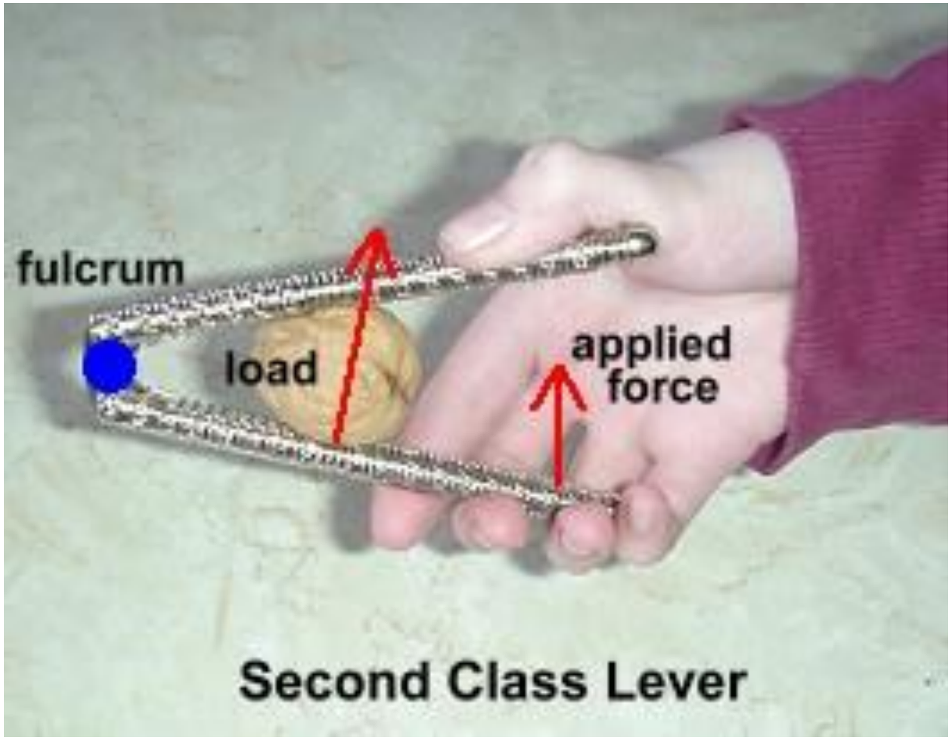
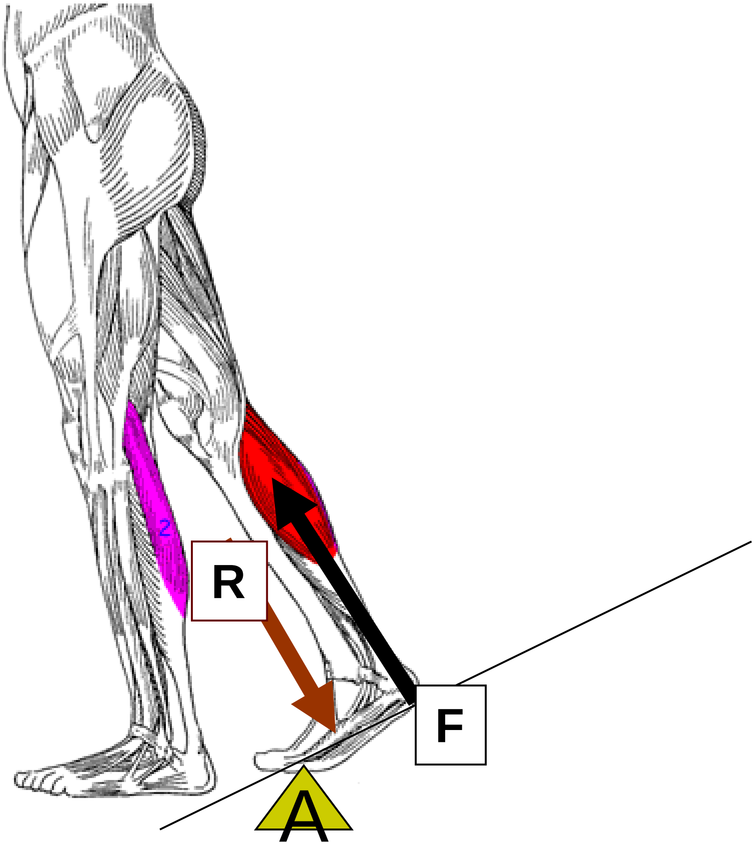


A R F

Second Class

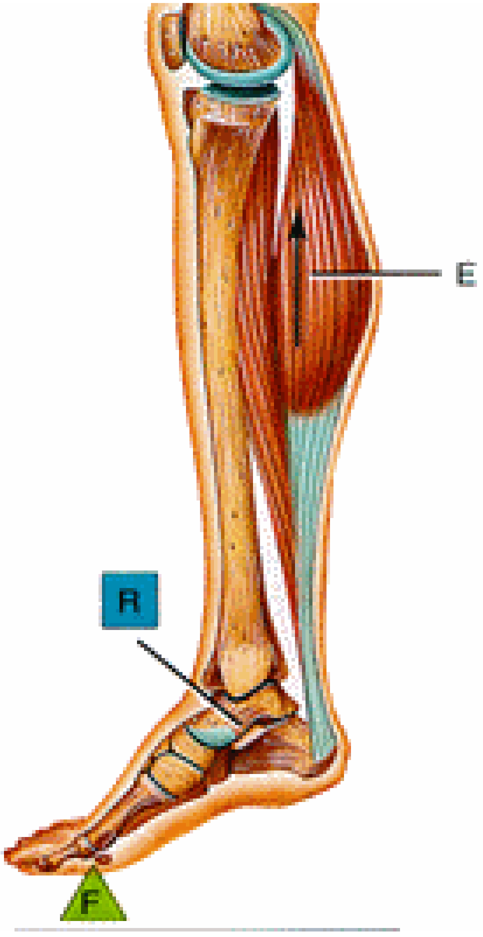


Second Class



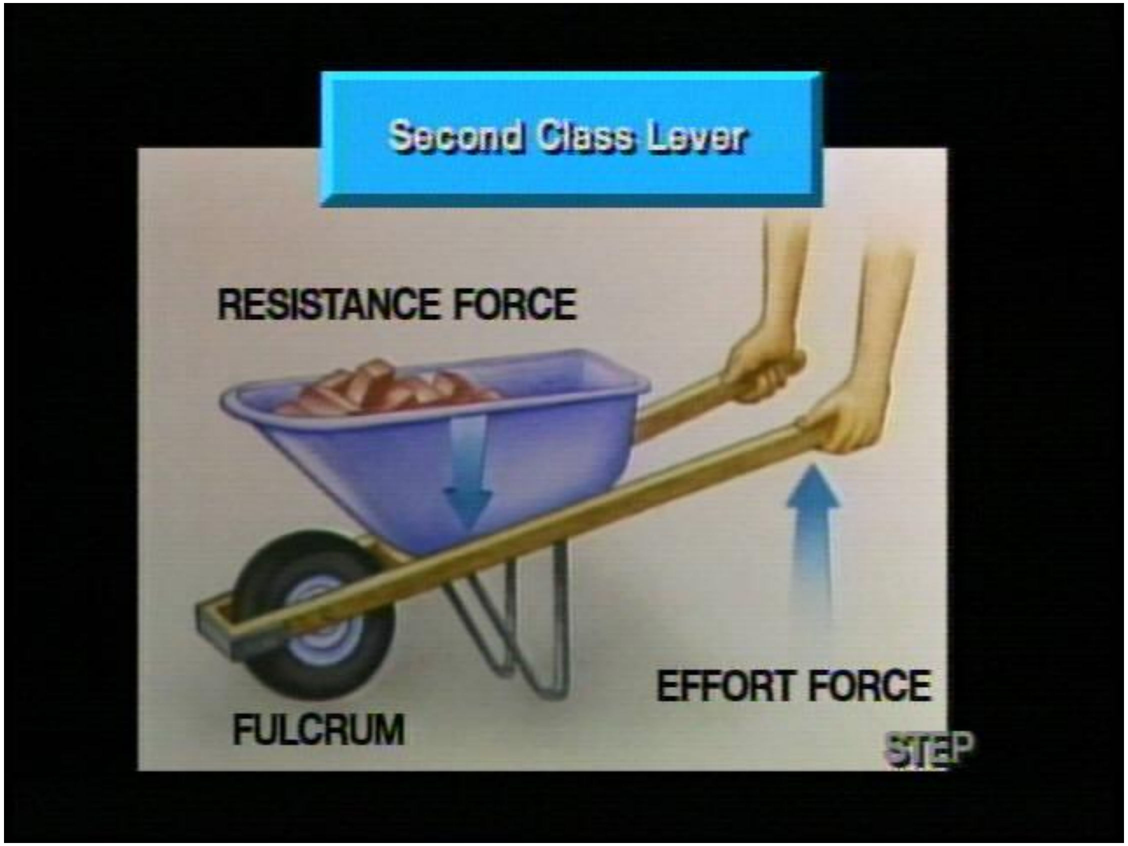
- Plantar flexion
- Gastrocnemius and Soleus

Second Class

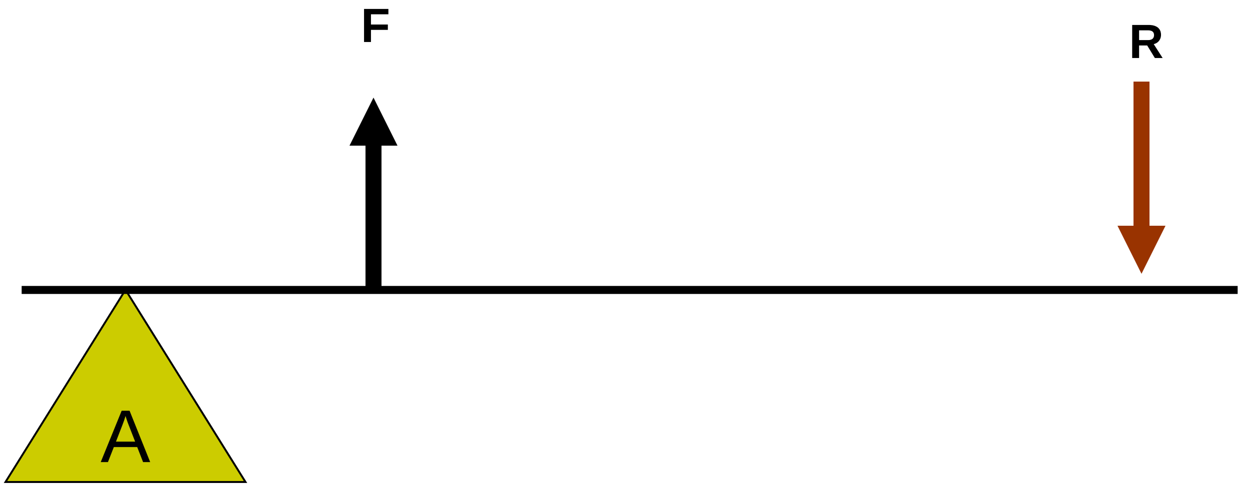


Second Class

- Designed more for force

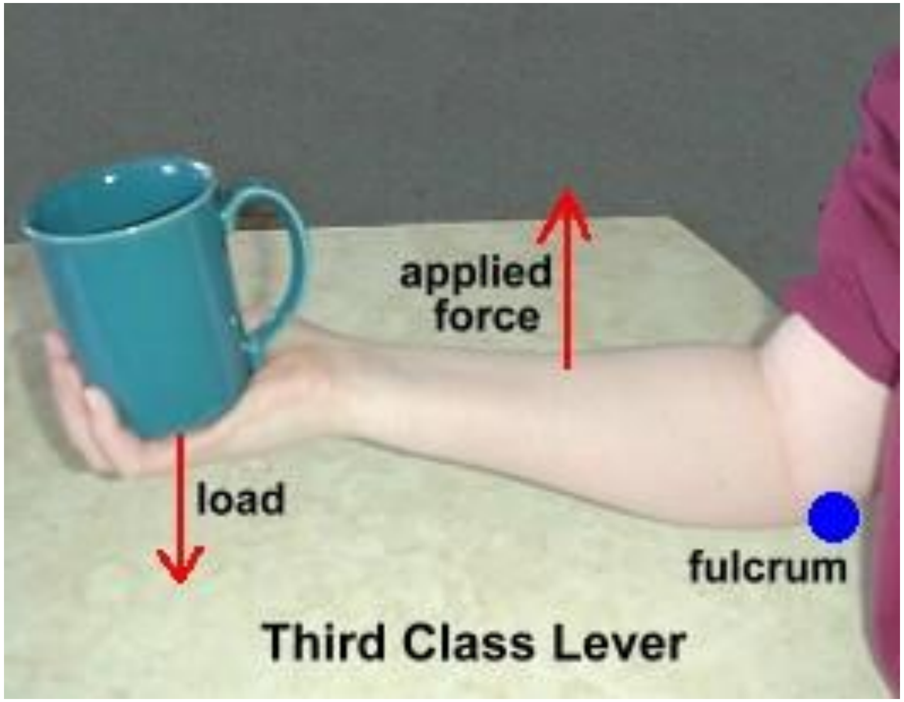


Third Class



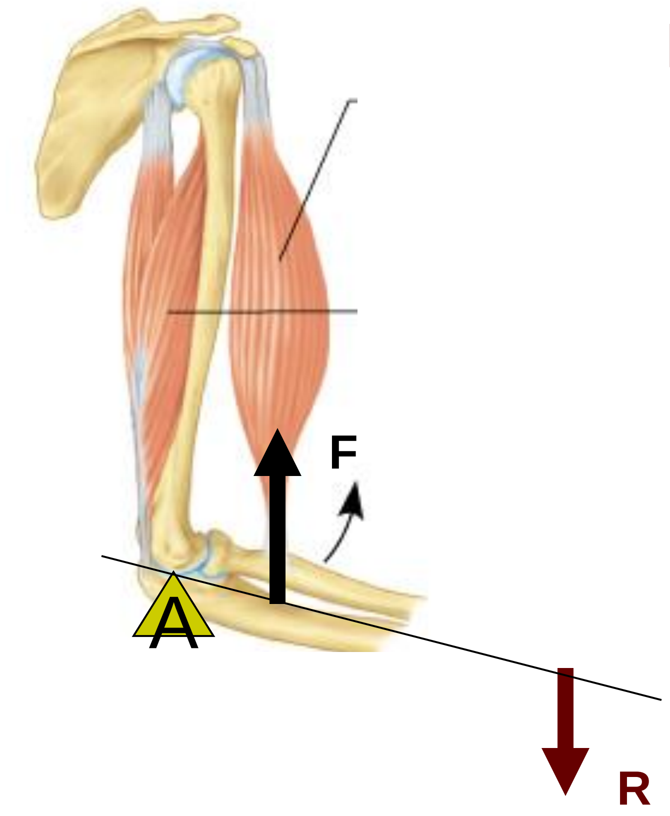
A F R

Third Class



Third Class

- Elbow flexion
- Biceps brachii and Brachialis



Third Class

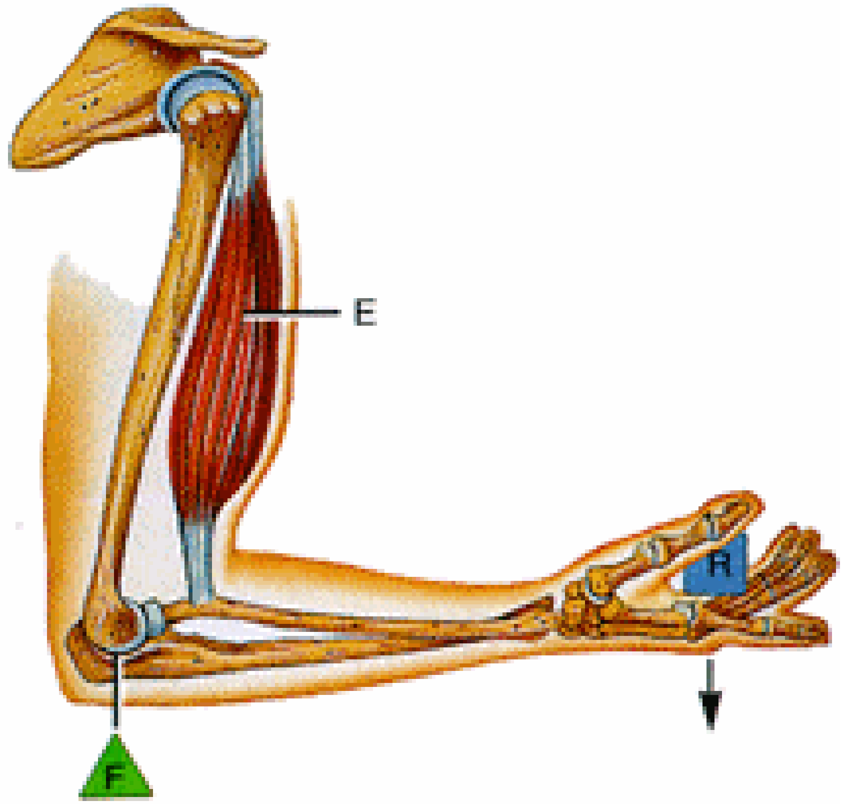
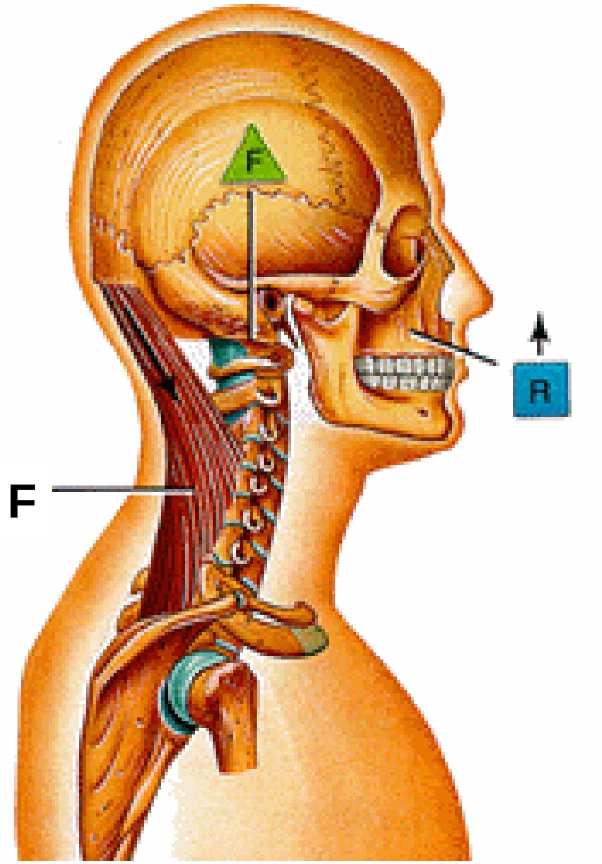


Table 3.1

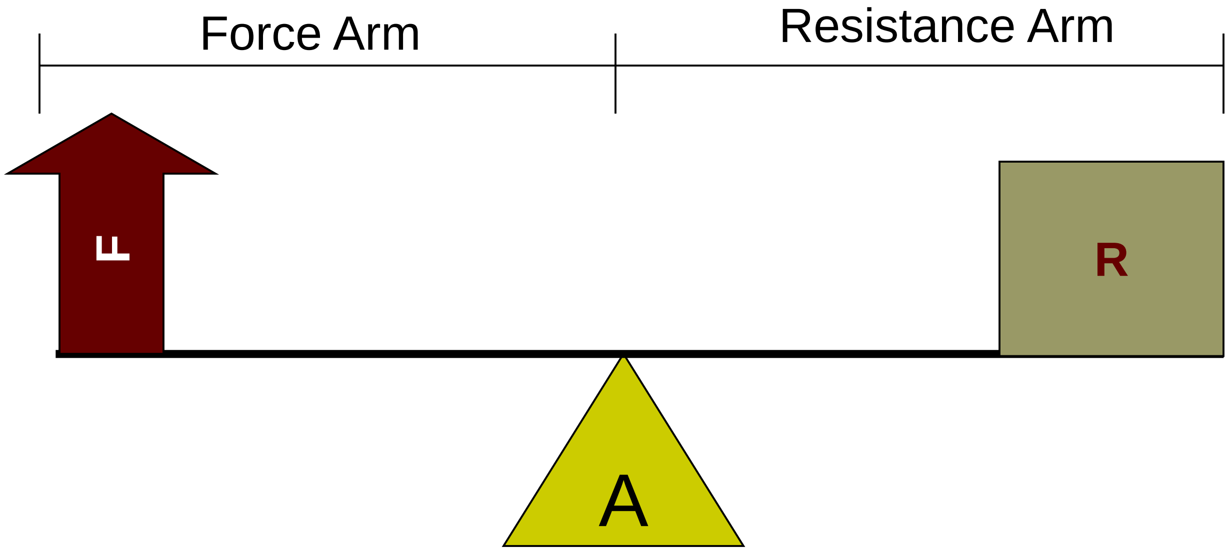
CLASS	ARRANGEMENT	ARM MOVEMENT	FUNCTIONAL DESIGN	RELATIONSHIP TO AXIS	PRACTICAL EXAMPLE	HUMAN EXAMPLE
1ST	F-A-R	Resistance arm and force arm in opposite direction	**Balanced movements**	Axis near middle	Seesaw	**Erector spinae neck extension**
			Speed and range of motion	Axis near force	Scissors	**Triceps**
			Force (Strength)	Axis near resistance	Crow bar	
2ND	A-R-F	Resistance arm and force arm in same direction	**Force (Strength)**	Axis near resistance	Wheel barrow, nutcracker	**Gatroc and soleus**
3RD	A-F-R	Resistance arm and force arm in same direction	**Speed and range of motion**	Axis near force	Shoveling dirt, catapult	**Biceps brachii**

Factors In Use of Anatomical Levers

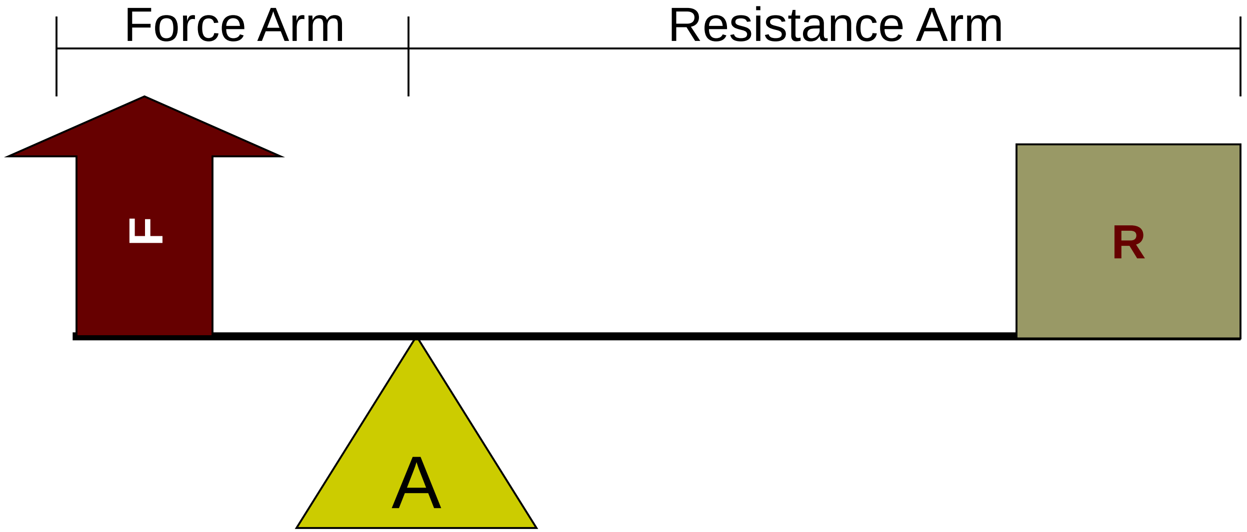
- A lever system can be balanced if the F and FA equal the R and RA



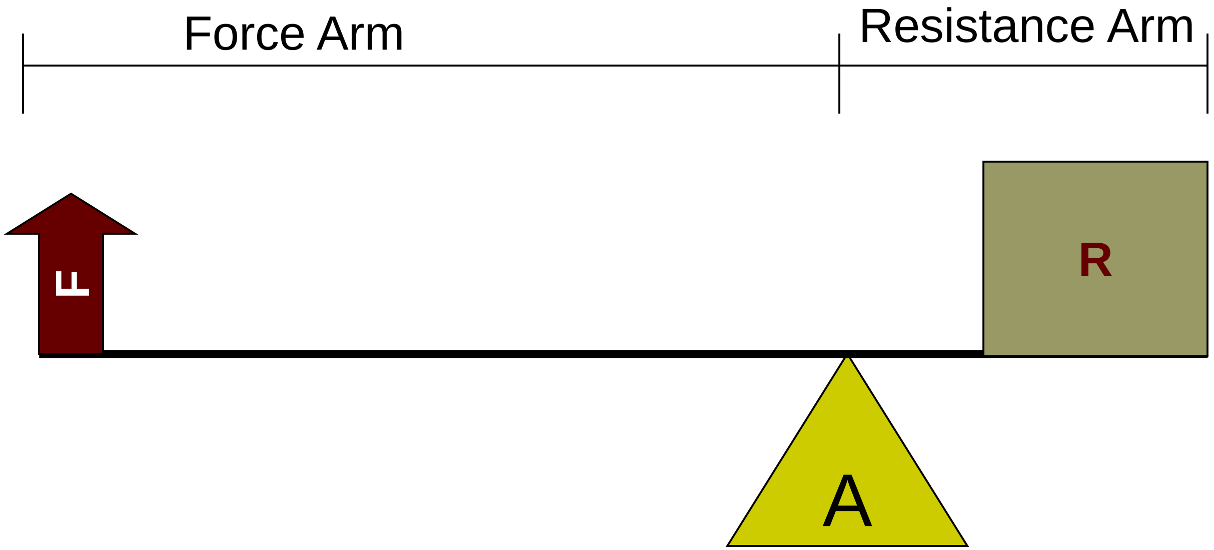
Balanced



Balance with More Force



Balanced with Less Force

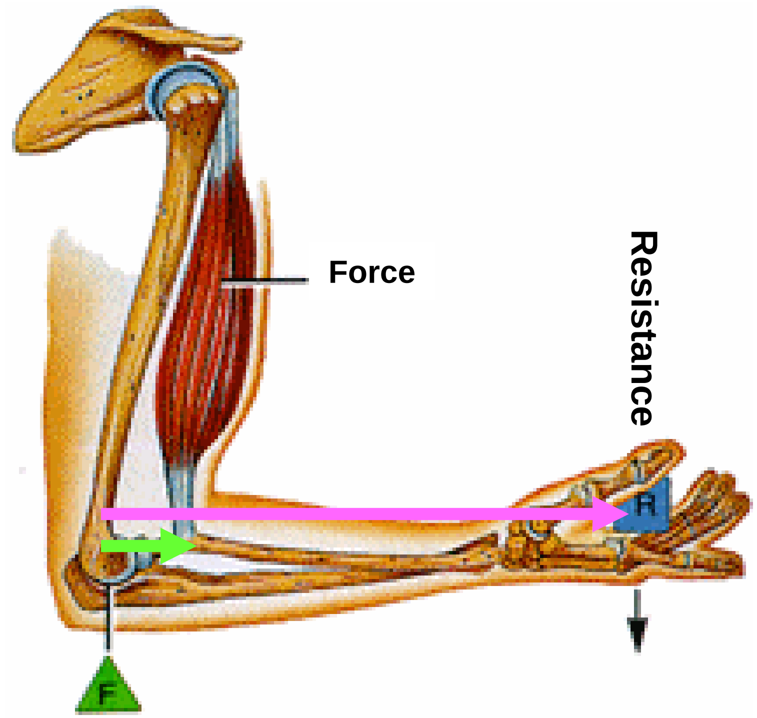


Factors In Use of Anatomical Levers

- A lever system can become unbalance when enough torque is produced
- Torque is the turning effect of a force; inside the body it caused rotation around a joint.
- Torque = Force (from the muscle) x Force Arm (distance from muscle insertion from the joint)

Practical Application

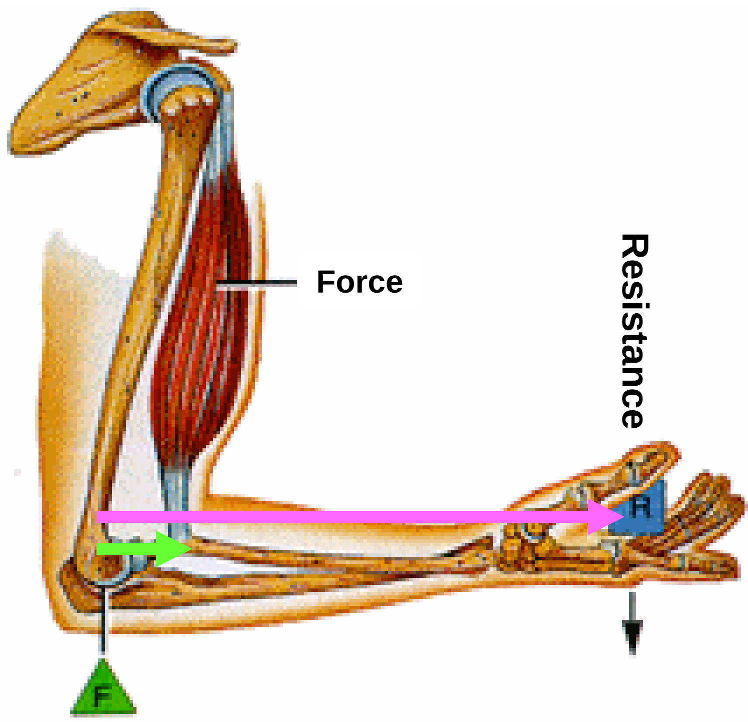
- Force is produced by the muscle
- FA the distance from joint (i.e. axis or folcrum) to insertion of the force
- Resistance could be a weight, gravity, etc.
- RA the distance from joint to the center of the resistance



Examples

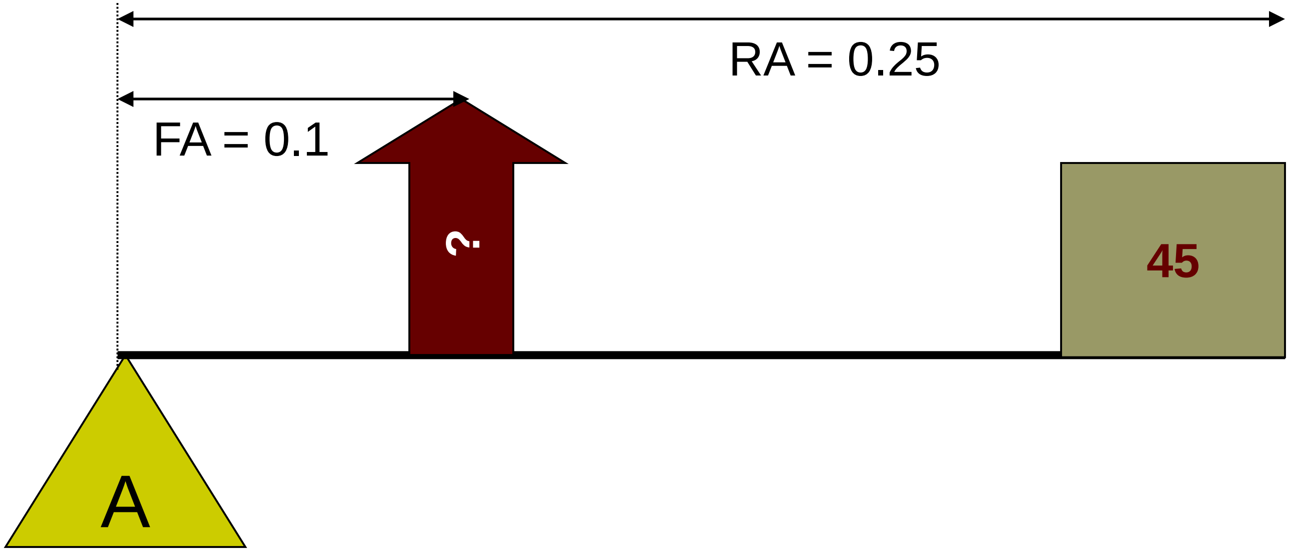
1. How much torque needs to be produced to move 45 kg when the RA is 0.25 m and the FA is 0.1 meters?

- Use the formula **F x FA = R x RA**
- Note: A Newton is the unit of force required to accelerate a mass of one kilogram one meter per second per second.



Example 1

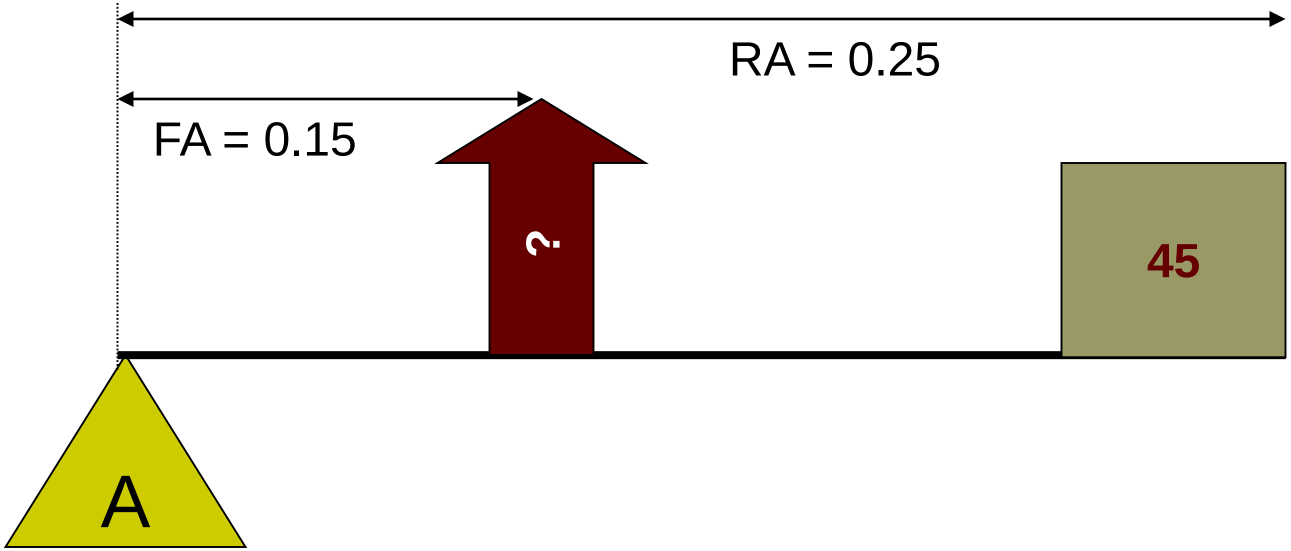
- F x 0.1 meters = 45 Kg x 0.25 meters
- F x 0.1 kg = 11.25 Kg-meters
- F = 112.5 Kg



Example 2: Increasing the FA

2. What if the FA was increased to 0.15 meters?

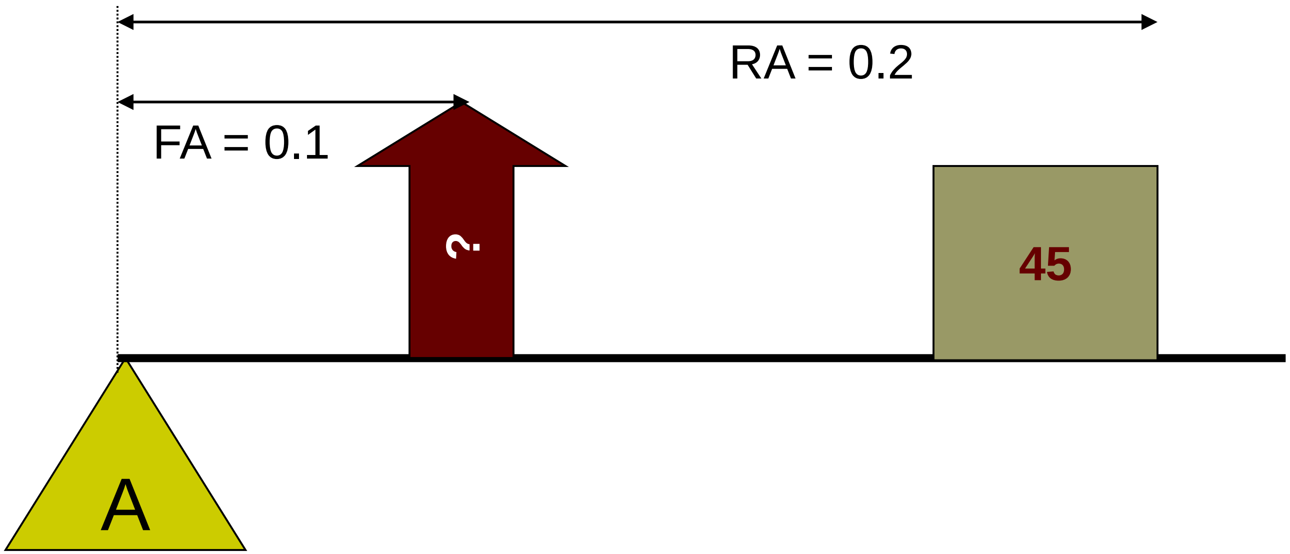
- F x 0.15 meters = 45 Kg x 0.25 meters
- F x 0.15 = 11.25 Kg-meters
- F = 75 Kg



Example 3: Decreasing the RA

3. What if the RA was decreased to 0.2 meters?

- F x 0.1 meters = 45 Kg x 0.2 meters
- F x 0.1 = 9 Kg-meters
- F = 90 Kg



Summary

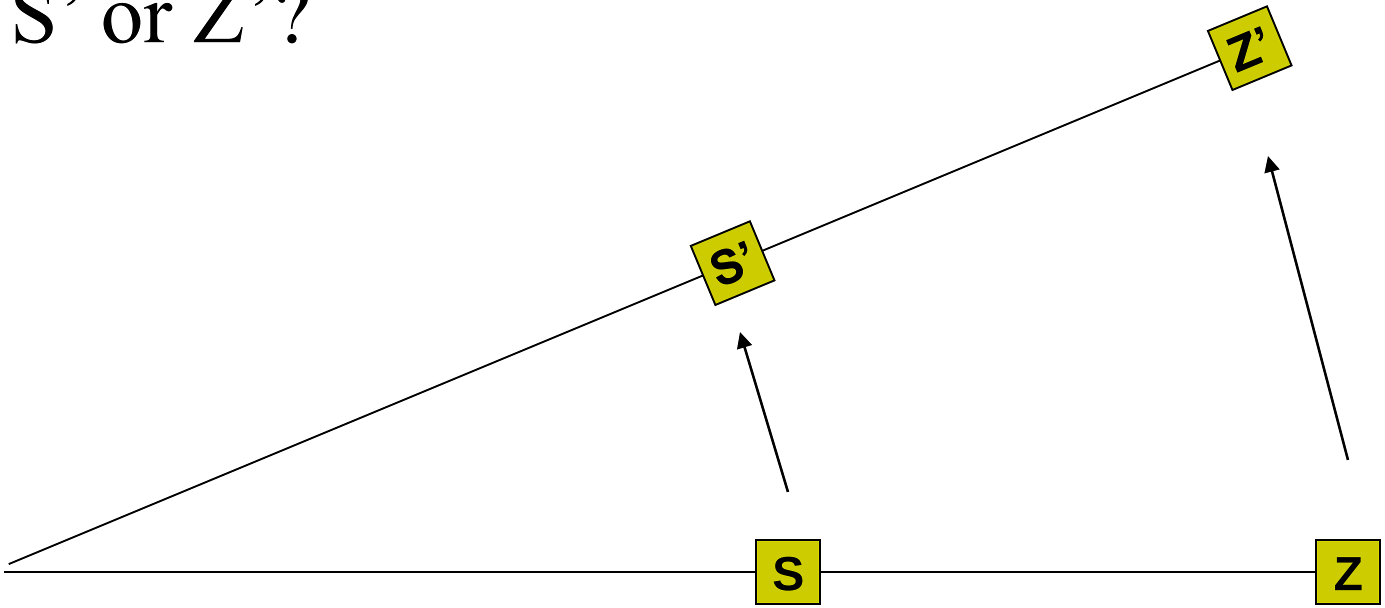
- The actual torque needed to move a given resistance depends on the length of the FA and RA
- As the FA increases or RA decreases, the required torque decreases.
- As the FA decreases or RA increases, the required torque increases.

Levers Continued

- Inside the body, several joints can be “added” together to increase leverage (e.g. shoulder, elbow, and wrist.
- An increase in leverage can increase velocity

Lever Length

- Where is the velocity or speed the greatest; at S’ or Z’?



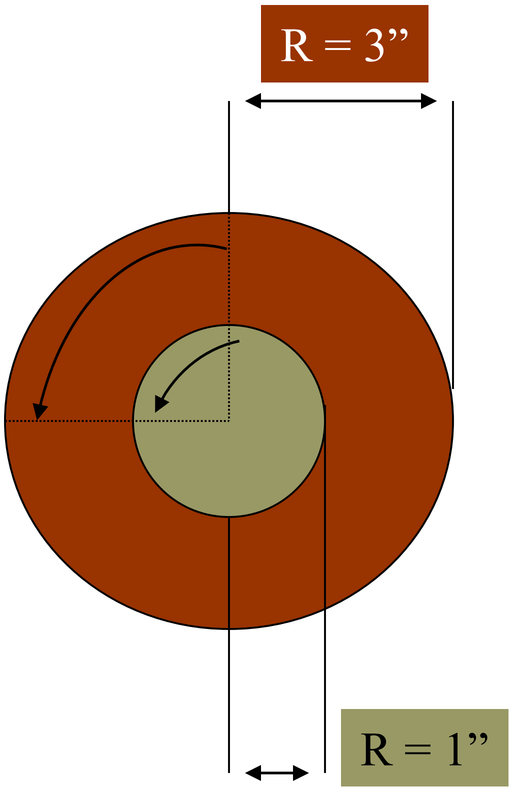
- How can this principle be applied to tennis?

Lever Length

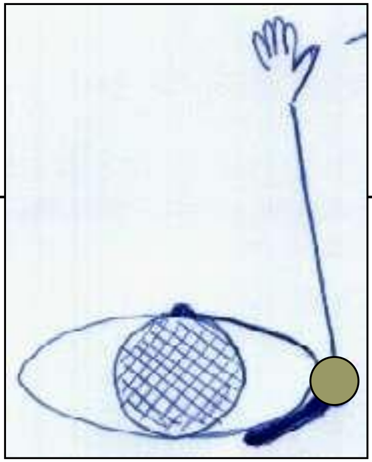
- A longer lever would increase speed at the end of the racquet unless the extra weight was too great. Then the speed may actually be slower.

Wheels and Axles

- Wheels and axles can enhance speed and range of motion
- They function as a form of lever
- Mechanical advantage = **radius of wheel** / **radius of axle**



Wheels and Axles



- Consider the humerus as an axle and the forearm/hand as the wheel
- The rotator cuff muscles inward rotate the humerus a **small amount**
- The hand will travel a **large amount**
- A little effort to rotate the humerus, results in a significant amount of movement at the hand